



Seasonal Variation Impacts on Informal Waste Collection in Ibadan, Nigeria

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Abstract

The study explores the impact of seasonal changes on the types and volume of waste handled by informal waste collectors (IWCs) in Ibadan, Nigeria. The research involved 253 IWCs who were surveyed using questionnaires and field observations. The results showed that the types and volume of waste collected varied from season to season. In the dry season, patronage was reduced by 25% due to less waste volume and increased burning. This reduced income by 25% on average. This raises concerns about job security for IWCs and the impact of increased burning on the atmosphere, leading to global warming. The study recommends financial and technical assistance from government or non-governmental organisations to help IWCs establish small waste merchandising businesses to cope with low patronage. This could help mitigate the adverse effects of seasonal changes on IWCs' operations.

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Introduction

Informal waste collection is an economic venture involving unorthodox means of waste collection and transportation, such as a cart, wheelbarrow, head pan, or basket, to collect, transport, and dispose of household waste for a fee. The informality of the operation of these groups of workers stems from the fact that they are not registered under the law, do not comply with legislated standards of quantity, minimum pay and safety and, more often than not, do not pay taxes (ILO, 2021). Elgin et al. (2021) also conceptualised informal economic undertaking as a process of income generation characterised by one central feature: it was unregulated by the institutions of society in a legal and social environment in which similar activities were regulated. Thus, the informal sector can be regarded as all unregulated economic activities outside the state's and its institutions' incentive system.

Studies have shown the effectiveness of informal waste collectors (IWCs) in waste management despite the rudimentary nature of their operation (Ola, 2016; Velis, 2017; Ogwueleka & Naveen, 2021). They have been mainly responsible for waste collection in the high-density neighbourhoods of cities, where formal collection is virtually non-existent (Wahab & Ola, 2016; Zisopoulos et al., 2023). For instance, Male (the capital of Maldives) lacks municipal waste service and informal waste collectors provide this service to most of the population in the city (Kapmeier & Gonçalves, 2018). Also, in Ciudad Nezahualcoyotl (Mexico), informal waste collectors served more than 70% of the pollution and earned five times the national minimum wage of Mexico (Gutiérrez-Galicia et al., 2021). In Lagos (Nigeria), it is estimated that over five thousand (5,000) informal waste collectors are operating within the waste service industry, and they are collecting over 50% of the total waste generated in the state (Omosimua et al., 2021). Despite some level of effectiveness observed in the activities of the IWCs in waste management, a significant challenge for the effective operation of this group of workers is the variation in the year's seasons and the accompanying weather futures.

Seasons on the earth's surface are the result of yearly revolutions of the earth around the sun in combination with the rotation of the earth, creating differences in heat distribution (National Geographic, 2023). The weather in the northern hemisphere is warmest during summer (dry season) because the sun is directly overhead at the Tropic of Cancer (Zhao et al., 2023). The northern hemisphere is colder in winter (rainy season) because the sun is over the Tropic of Capricorn (Zhao et al., 2023). Thus, the dry season is a

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yearly period of low rainfall, especially in the tropics. The weather in the tropics is dominated by the tropical rain belt, which moves from the northern to the southern tropics and back over the year (Visser et al., 2021). The tropical rain belt lies roughly from October to March in the southern hemisphere. During this period, the northern tropics have a dry season with sparser precipitation, and days are typically sunny. The rain belt lies in the northern hemisphere from April to September, and the southern tropics have their dry season.

Under the Köppen climate classification for tropical climates, a dry season month is a month with average precipitation below 60 millimetres (Schroeer & Kirchengast, 2018). Because the dry season has low humidity, the lack of water affects a slight shift in people's consumption patterns, as less leaf-related food and fruits are consumed. Usually, there is a higher concentration of people in the urban centres in the dry season, as agricultural activities are virtually impossible without irrigation. These make some farmers move into cities, creating hubs of higher population density and, consequently, generating more waste. However, the dry season offers more opportunities for residents to burn their waste, reducing the quantity of waste available for collection.

The rain belt reaches roughly as far north as the Tropic of Cancer and south as the Tropic of Capricorn. Near these latitudes, there is one wet season and one dry season annually (Sun & Wang, 2022). At the equator, there are two wet and two dry seasons, as the rain belt passes over the equator twice a year, once moving north and once south. Between the tropics and the equator, locations may experience a short-wet and a long-wet season and a short dry and a long dry season. However, local geography may substantially modify these climate patterns (Sun & Wang, 2022).

A close look at the literature revealed that fewer research efforts have been focused on investigating how the seasons of the year affect the activities of the IWCs concerning waste collection, transportation and disposal, and patronage. Instead, many authors have concentrated on analysing the effects of seasonal variation on the types and volume of municipal or domestic waste generated (Rhyner, 1992; Gómez et al., 2009; Boldrin & Christensen, 2009; Denafas et al., 2010; Mshelia, 2015; Zia et al., 2017). This is the motivation for this study, which attempted to fill this gap by looking at the effects of seasonal variations on the activities of IWCs, focusing on Ibadan, a large conurbation and a regional capital with a significant number of active informal waste collectors.

Literature Review

The interplay of climatic features gives rise to seasons. Therefore, climate change greatly influences the occurrence and variations of the seasons. Much of the waste generated in rural and urban communities in Nigeria is either burnt or left to rot, and this constitutes a significant source of the country's contribution to greenhouse gas emissions (Uwejamomere, 2003; Wahab, 2009). Gases that trap heat in the atmosphere are often called greenhouse gases. According to the United States Environmental Protection Agency (USEPA) (2012), some of these gases emitted to the atmosphere through burning solid waste, among other human activities, are carbon dioxide, methane, nitrous oxide, and fluorinated gases. These gases are ozone-depleting substances, sometimes called high global warming potential gases. The consequences of ozone depletion are the various environmental hazards (like floods, tsunamis, and fire outbreaks) witnessed in virtually every part of the world in the last few decades (IPCC, 2017; USEPA, 2017). Ibadan experienced annual flood disasters from 2011 to 2017, and fire incidents occurred in different parts of the city, with indiscriminate waste dumping and burning being causal factors. The intensity of these hazards in recent times calls for greater attention by policymakers and researchers.

Enete (2010) argues that climate change could result in changes in temperatures, cloud cover, rainfall patterns, wind speeds and storms, all of which could impact waste management facilities' development and operation. The time scales for climate change and waste management are similar. For instance, landfill sites can be operational for decades and remain active for decades following their closure. Therefore, there is a need to consider potential changes in waste management over significant timescales and respond appropriately. In a report by USEPA (2016), waste reduction through recycling of about 35 per cent of waste is estimated to reduce greenhouse gas emissions by 11.4 million metric tons of carbon equivalent (MTCE, the basic unit of measure for greenhouse gases) over landfilling the same material. The report further noted that waste prevention also makes a significant difference: by cutting the amount of waste that humans generate by just 5 per cent, greenhouse gas emissions can be reduced by another 10.2 million MTCE. United Nations Environment Programme (UNEP) (2010) had earlier observed that the waste management sector is in a unique position to cease to be a source of emissions of greenhouse gases (GHG) overall to become a significant

contributor to the reduction of greenhouse gas emissions.

Although waste management in developing countries has been characterised mainly by municipal collection and formal private sector participation, the inability of the two actors to achieve a reasonable collection rate allowed waste to accumulate in the environment, thereby threatening public health and partly inducing negative climate change. Attempts to fill the vacuum created in waste management led to the emergence of IWCs, which are active in waste collection in Nigeria and some developing countries, such as Ethiopia, India, Kenya, Brazil, and South Africa.

As in other countries, the volume and type of waste generated in Nigeria are influenced by seasonal variation. In his study of Oyo, Nigeria, Afon (2006) found that 1,093 tons of waste were generated in July (wet season), while 774 tons were generated in February (dry season). Leaves were the dominant waste in the dry season, while paper was the dominant waste in the wet season. The preponderance of paper in the wet season can be explained by the fact that paper is mainly used to wrap cold palp, bean cake (*akara*), *mossa*, *moin-moin* and other local snacks, such as puff-puff, for consumption owing to the shortage in the supply of leaves. The wet season is the growing period for leaves harvested in the dry season. In the Mubi metropolis, Nigeria, according to Mshelia (2015), 26,378 households have a daily waste generation of 1435.6 kg (2.7kg/household/day) in the wet season and 1658.5 kg/day (3.1kg/household/day) in the dry season. While garbage is generated the most in the wet season (432.5kg/day), ashes are generated the most in the dry season (481.1kg/day).

This seasonal variation has been found to affect the volume and type of waste evacuated by IWCs in several countries. PCI (2008) notes that in Manila, Philippines, ash/earth and vegetables were the dominant wastes collected by the IWCs in the wet season, while paper and plastic waste predominated in the dry season. While the IWCs collected about 4000 tons of waste monthly in the wet season, some 3100 tons were collected in the dry season (PCI, 2008). However, despite the variation in the volume of waste collected by the IWCs, the author does not give the variation in the income in both seasons, as the study only revealed a daily earning of US\$5-10 by the IWCs in the city. Kamran et al. (2015) claim that, in Lahore, Pakistan, the average weekly waste collection by the IWCs in the wet and dry seasons was 1200 tons and 1050 tons, respectively.

The dominant wastes in wet and dry seasons were vegetables and rubber. The study, however, does not give information on the income from waste collection or the variation in the income. No variation in the volume and types of waste collected by the IWCs was also found in Porto Alegre, Brazil, as reported by Gutberlet (2008), where the IWCs served 79% of the city's 1.1 million population and evacuated 100 tons of waste monthly. The dominant wastes were vegetables and paper. The waste collectors earned about US\$300 monthly, twice Brazil's minimum wage. The IWCs in Egypt, known as Zabaleen, collected 2,700 tons of mainly food waste per day in the wet season, nearly 50% of Cairo's daily total waste of 6,000 tons (Slackman, 2009). However, a slightly higher volume of waste (2,817 tons) was collected in the dry season.

The dominant wastes collected in the dry season were paper, plastic and glass (Slackman, 2009). The departure from the situations in other cities reviewed earlier and the recyclable nature of the dominant wastes collected in Egypt in the dry season may be attributed to the well-organised waste recycling activities of the Zabaleens. As earlier observed by Fahmi and Keith (2006), the Zabaleen recycled as much as 85% of their collected waste. However, none of the authors reported the variation in Zabaleens' income. Apart from the shortcomings identified in the previous works, none of the studies ventured into identifying the effects of seasonal variation on waste transportation and disposal by the IWCs. This study filled the observed gap.

Study Area and Methodology

Ibadan is between longitude 7°20'E and 7°40'E and latitude 3°35'N and 4°10'N. It is 145km northeast of Lagos and 345km southwest of Abuja, the Federal capital (Figs. 1, 2 and 3). Ibadan enjoys the West African monsoonal climatic type, marked by two distinct seasons. The rainy season falls between March and October when the moist monsoonal wind from the Atlantic Ocean blows over the region. The dry season falls between November and February owing to the influence of the dry, dust-laden northeast trade winds from the Sahara Desert (Oguntinyinbo, 1994). The mean annual rainfall in Ibadan between 1911 and 1988 was 1258.9 mm. However, monthly and yearly values of rainfall generally fluctuate. For instance, a value of 151 mm was recorded for April 1997, while August 2011 recorded 187.5 mm (NMS, 2011, cited in Oyo State Government [OYSG], 2011). The mean temperatures are highest at the end of the harmattan (averaging 28°C), from the middle of January to the onset of the rains in the middle of March. Even during the rainfall, average temperatures are relatively high, between 24°C and 25°C, while the annual temperature fluctuation is about

6°C (OYSG, 2011).

The development of Ibadan has been influenced by traditional and colonial urbanisation. The city's population in 1856 was about 60,000, and by 1890, it had increased to about 200,000. The population grew to 627,379 in 1963, 1.2 million in 1991, and 2.6 million in 2006 (Afolayan, 1994; FRN, 2007). Using a 3.2% growth rate as recommended by the National Population Commission (NPC) (NPC, 2007), the 2023 population of Ibadan was estimated at 3.9 million.

The increasing demographic figures of Ibadan have played a dominant role in the volume of waste generated in the city over the years. For instance, in the late 1960s and the early 1970s, the estimated solid waste generation rates for Ibadan's inner city and suburban districts were between 0.37 to 0.50 kg/capita/day and 0.53 kg/capita/day, respectively (Maclaren, 1970). In the 1980s, PAI Associates (1982) estimated the solid waste generation rate of 3.4 kg/household/day in the core areas, 3.2 kg/household/day in the suburbs and 3.3 kg/household/day in the whole city. This gave a per capita generation rate of 0.33 kg/day. Also, a study by Oluwande (1983) revealed a per capita waste generation of 0.42 kg/day in the government-reserved areas (GRAs), 0.38 kg/day in the urban fringe and 0.35 kg/day in the traditional areas. Sridhar et al. (1985) estimated 0.428 kg, 0.289 kg and 0.132 kg refuse per capita among families in high, middle and low socio-economic groups, respectively, in Ibadan, while the estimates by Ayorinde et al. (2010) put the daily per capita solid waste generation for Ibadan at 0.52 kg.

The city's statutory body responsible for waste management is the Oyo State Solid Waste Management Authority (OYOWMA) under the Ministry of Environment and Water Resources. The OYOWMA waste collection and disposal activities are complemented by private refuse companies (PRCs) licensed by the state government to undertake waste collection, particularly in the low-density residential areas of the city (Oyo State of Nigeria, 2013). There were 259 PRCs in 2013 (OYOWMA, 2013), which increased to 400 in 2016 (Hammed et al., 2016). However, the combined activities of both the public actor (OYOWMA) and the organised private refuse contractors have not translated into effective waste management services in Ibadan, as only 10% of the 485,860,260 kg of solid waste generated annually in the city is evacuated (Hammed et al., 2016). However, the informal private sector is found to be very active in the city's solid waste management scheme (Wahab & Ola, 2016).

Methodology

Data for this study were collected through a questionnaire survey, field observations, and actual waste volume measurements. The questionnaire was administered in May (wet season) and December (dry season) in 2021. A pre-tested structured questionnaire was administered to 253 (50%) of the 506 informal waste collectors identified in the city's five municipal local government areas. The fifty per cent sample size conforms with Neuman's (1994) assertion that for small populations (under 1,000), a researcher needs a large sampling ratio (about 30 to 50 per cent). The 90-item questionnaire was designed to obtain information on the types and volume of waste collected by IWCs in both dry and wet seasons in the city, as well as how the seasons affect both the rate of patronage of the collectors and the collectors' income, among others. The questionnaire was prepared in English and administered by four trained field assistants who were graduates and could translate the questions into the native language of the respondents who did not understand English.

Questionnaire administration was conducted daily between 8 am and 6 pm for six days, from Saturday to Thursday. Completed copies of the questionnaire for each day were checked for errors or ambiguous responses. The trained research assistants used A hand-held balance scale to measure the volume of the waste collected by the IWCs over seven days in both the wet and dry seasons. Through the cooperation and permission of the sampled informal waste collectors, the researchers also observed and sorted the waste collected by each collector over seven days to determine the types and volume of garbage collected. All 253 copies of the questionnaire administered were returned for analysis.

Data collected were analysed using the Statistical Package for Social Sciences (SPSS) software (Version 20) and presented using descriptive statistics in the frequency distribution of the types of waste collected and inferential statistics. Analysis of Variance (ANOVA) was employed to determine the statistical significance of the variations in the types and volumes of waste collected by the IWCs. Ethical issues were given due consideration regarding the purpose of the study, contents of the research instrument, acceptance of respondents' right to privacy, confidentiality of the data, and informed consent and willingness of the respondents to answer questions.

Results and Discussions

This section discusses how variations in the year's seasons affect the types and volumes of waste informal waste collectors collect. The study location enjoys short, dry, and long rainy seasons. Some (60.1%) of the sampled informal waste collectors stated that seasonal difference affected their business, while 39.9% said otherwise. Of those whose business was affected by seasonal differences, 42% indicated the wet season as the period in which they recorded more patronage, while 18.1% indicated the dry season. The IWCs handled 255kg of waste in the wet season, compared to 203kg in the dry season. The higher volume of waste generation during the wet season, as established by Afon's (2006) study, was observed to be responsible for the high demand for waste collection services in the wet season.

Types of Waste Collected in Wet and Dry Seasons

Findings established that seasons affected the types of waste collected by the IWCs as claimed by 80.2% of them. Table 1 shows the components found in the waste collected by the IWCs. The dominant wastes collected in the wet season were maize husk, 15.7%; leaves, 14.2%; human excreta, 11.9%; fruits, 11.1%; vegetables, 9.9%; glass, 6.7%; and others, 30.5%. The dominant wastes collected in the dry season were polythene, 14.2%; construction debris, 11.9%; ash/dust, 10.3%; textiles, 9.1%; and others, 54.5% (Table 1). The households generated the waste during the seasons.

Table 1: Components of Waste Evacuated by Informal Waste Collectors in the Wet and the Dry Seasons

Types of Wastes in the Wet Season			Types of Waste in the Dry Season		
Wastes	Freq.	%	Wastes	Freq.	%
Leaves	36	14.2	Dead Animals	15	5.9
Maize Husk	40	15.7	Polythene	36	14.2
Vegetables	25	9.9	E-waste	17	6.7
Fruits	28	11.1	Plastic	21	8.3
Human Excreta	30	11.9	Construction Debris	30	11.9
Textiles	7	2.8	Wood	11	4.3
Paper	16	6.3	Leaves	15	5.9
Polythene	12	4.7	Maize Husk	5	2.0
Glass	17	6.7	Vegetables	9	3.6
Plastic	14	5.5	Fruits	11	4.3
Ash/Dust	6	2.4	Human Excreta	5	2.0
Wood	5	2.0	Textiles	23	9.1
e-waste	4	1.6	Paper	5	2.0
Dead Animals	6	2.4	Ash/Dust	26	10.3
Construction Debris	7	2.8	Glass	24	9.5
Total	253	100.0	Total	253	100.0

The dominant wastes collected in both seasons in Ibadan appear to conform to the pattern from other cities reviewed— Lahore (Pakistan), Porto Alegre (Brazil), and Manila (Philippines)— (PCI, 2008; Gutberlet, 2008; Kamran et al., 2015). This could be explained by the socio-economic development in Ibadan and those cities at a level, hence the preponderance of food (organic) waste. Variation in the types of waste collected in the dry and wet seasons was statistically significant, as the F value of the computed ANOVA was 12.99 at $p = 0.019$.

Naturally, the availability of enormous quantities of crop residues (such as maize, yam, cassava, and fruits of different types and vegetables) associated with the wet season and the tendency for people to consume more during this period owing to the low prices of most of these agricultural residues usually lead to more waste generation and consequently high demand for waste service providers. Also, the difficulty in burning some of the wet waste within or around houses, as practised by some households during the period, made it imperative for them to require waste service providers. The preponderance of nylon or polythene (mostly from packaged water sachets and consumed local food, such as *àràlà*, *fufú*, *iyán* and *èbà*), glass (mostly broken bottles) and plastic in the dry season was as a result of social engagements and religious celebrations (Christmas and New Year) that generally characterised the period. Naturally, in Yoruba land (part of which is Ibadan), people prefer slating their social engagements (especially weddings, house-warming, annual meetings and

development programmes by town unions and other indigenous organisations) for the dry season to avoid possible disturbance by rainfall and to enable farmers to participate, as they would have less to do on the farm.

Volume of Waste Collected in the Wet and the Dry Seasons

Table 2 summarises the data from the field survey on the volume of waste collected by the informal waste collectors in both seasons. Analysis of the data for the wet season indicated that the amount of garbage evacuated in a week by each of the sampled waste collectors ranged from 172 kg to 3400 kg. Although some (15%) evacuated 1,845 kg in a week, on average, a collector evacuated 255 kg per day, 1,786 kg per week, 7,905 kg per month and 94,860 kg per year. Putting all the 253 sampled informal waste collectors into consideration, it could be deduced that the sector was responsible for evacuating about 64,515 kg (64.5 tons) per day, 451,858 kg (452 tons) per week, 1,999,965 kg (2000 tons) per month and 23,999,580 kg (24,000 tons) per year (Table 2). Applying these collection rates to the 506 IWCs enumerated in the study area revealed that the informal waste sector was responsible for evacuating during the wet season about 129,030 kg (129 tons) per day, 903,210 kg (903 tons) per week, 3,999,930 kg (3,999 tons) per month and 47,999,160 kg (47,999 tons) per year.

A comparison of the volume of waste evacuated in the wet season by the IWCs in Ibadan and other cities reviewed earlier showed an apparent disparity. While the daily volume of garbage collected by IWCs in Cairo and Lahore in the wet season was more than that of Ibadan, a lesser volume of waste was collected in Manilla (PCI, 2008; Slackman, 2009; Kamran et al., 2015). The factors that could account for this may be the level of organisation of the IWCs in those cities, official policies on informal waste collection, access to capital for acquisition of modern waste collection equipment, patronage rate of the IWCs and income accruable from waste collection business.

The dry season data revealed that the amount of waste evacuated by each IWCs in a week ranged from 87kg to 2,240kg. Some (34.4%) of the sampled waste collectors evacuated between 87 kg and 125kg; some (47.2%) evacuated between 125.1kg and 135kg; and 10.8% evacuated between 135.1 and 170 kg. Some (15.4%) evacuated about 500 kg, 18.6% evacuated about 1,000 kg, while some (9%) evacuated about 1500 kg. Some (3.4%) IWCs evacuated above 2,000 kg. Only one waste collector evacuated about 2,240 kg of refuse in a week.

Further analysis showed that an informal waste collector's average daily collection rate was 203 kg, while the weekly collection rate was 1,421 kg. The average monthly collection rate stood at about 6,293 kg, while an informal waste collector evacuated about 75,516 kg of refuse annually. Thus, considering the 253 informal waste collectors sampled, it is evident that an average of 51,359 kg (51 tons) of waste was evacuated daily; the weekly collection rate stood at 359,513 kg (359 tons); 1,592,129 kg (1,592 tons) was collected monthly; while 19,105,548 kg (19,105 tons) of waste was collected in a year (see Table 2). These collection rates, when applied to the 506 IWCs enumerated in the study area, showed that the informal waste sector was responsible for evacuating during the dry season about 102,718 kg (102 tons) daily, 719,026 kg (719 tons) weekly, 3,184,258 kg (3,184 tons) monthly, and 38,211,096 kg (3,821 tons) yearly.

Like in the wet season, there was also an apparent disparity in the volume of waste collected in the dry season in Ibadan from other cities reviewed (PCI, 2008; Slackman, 2009; Kamran et al., 2015). The higher volume of waste collected by the IWCs in the wet season in Ibadan conforms to the pattern observed in other cities reviewed.

As shown in Table 2, an annual evacuation rate of 23,999,580 kg was recorded in the wet season, against 19,105,548 kg in the dry season, with a mean collection rate of 21,552,564 kg per annum. The computed ANOVA ($F = 19.08$ at $p = 0.05$) established that variation in the volume of waste collected in the wet and dry seasons was statistically significant. The higher volume of waste collected in the wet season might result from the preponderance of high-density waste that usually characterises the season (Zubrug, 2003; Nabegu, 2010). The reduction in the volume of waste in the dry season might be attributed to the low agricultural residues in this season and the observed tendency of the city's residents to burn their waste (especially leaves, paper, textiles, vegetables, and maize husk) by taking advantage of the pervasive dryness in the dry season which favours waste burning. The tendency for people to consume less food (mainly fruits and vegetables) owing to the reduced production of fruits and vegetables in the dry season is partly responsible for the reduced volume of waste during the dry season.

Table 2: Volume of Waste Evacuated by the Informal Collectors in the Dry and the Wet Seasons

Period	Wet Season		Dry Season		Mean Collection Rate (kg)
	Evacuation/ Collector (kg)	Evacuation/ All (kg)	Evacuation/ Collector (kg)	Evacuation/ All (kg)	
Daily	255	64,515	203	51,359	57,937
Weekly	1786	451,858	1,421	359,513	405,686
Monthly	7905	1,999,965	6,293	1,592,129	1,796,047
Yearly	94860	23,999,580	75,516	19,105,548	21,552,564

60.1% of the sampled waste collectors claimed that client patronage was affected in both seasons, with the dry season being the period when patronage was usually at its lowest. This influenced the number of waste evacuation and disposal trips the waste collectors could make and, consequently, their income. About 40.6% of the waste collectors claimed that the number of daily waste evacuation and disposal trips dropped by twenty-five per cent, while 11.2% and 8.2% experienced a drop in the number of waste evacuation and disposal trips by about fifty per cent and seventy-five per cent, respectively. A collector realised an average of ₦500 per trip, and collectors made an average of four daily trips (Wahab & Ola, 2016). This indicates that an average of ₦2000 was realisable per day by a collector. However, with the drop in the number of trips, these collectors could only make a daily average of ₦1500, ₦1,000 and ₦500, with the 25%, 50% and 75% drop in the number of daily collection trips, respectively.

The primary effect of the wet season on informal waste collection was the inability to move freely from one house to another and the waste dumpsites owing to poor road conditions, as stated by 40% of the sampled waste collectors. Potholes filled with murky water on the routes to the dumpsites and slippery unpaved roads within the neighbourhoods hampered the smooth movement of the waste carts operated by the waste collectors. Also, 20.1% of the IWCs claimed that whenever rain was falling, it was virtually impossible to affect waste collection from clients because the waste collectors could not work in the rain. Clients would equally not bring out their waste in the falling rain.

This limited the number of trips that the informal waste collectors could make. The implications are that less waste could be collected per disposal (leaving the environment with a high volume of uncollected waste). The IWCs could realise less income. Waste disposal in the wet season was equally done with a small quantity of difficulty by the IWCs, as 73.6% claimed that as a result of the poor state of the roads to their dumpsites, they spent more extended time disposing of their waste. This contributed to reducing the number of trips in the wet season and, by inference, their realised income.

Conclusion and Recommendations

It has been shown that variation existed in the types and volume of waste evacuated by the IWCs in the wet and the dry seasons, with maize husks and polythene being the dominant wastes in both seasons. While the average volume of waste collected by the IWCs in the wet season daily was 255kg, 203kg was evacuated daily in the dry season. With a waste collector making an average of four trips in the wet season and realising about ₦2000 in a day, the reduction in the volume of waste in the dry season led to a drop in the number of trips and a decrease in the income accruable from the waste collection business by about 25%. The study concluded that while the wet and dry seasons affected the volume of waste collected and the income realised by the IWCs in Ibadan, their prompt and regular waste collection and disposal services are continuously required and demanded by their clients across the seasons.

The problem of reduced patronage of IWCs in the dry season raises concerns about job security in the informal waste collection business. Considering the positive role the IWCs have been playing in the waste management scheme of Ibadan, as alluded to by Wahab and Ola (2016), and the fact that the ability of the formal collection system to affect the total evacuation of waste in the city in the nearest future is doubtful, efforts should be made to ensure that this group of informal waste workers are effectively kept in the waste management scheme of the city.

Indeed, more people should be encouraged to join the business, especially given Nigeria's high unemployment rate (NBS, 2023). This can be achieved by providing financial assistance to the waste collectors to establish a small waste merchandising business (through which the IWCs can serve as middlemen between the waste scavengers and the formal and informal recyclers) during the period of low patronage. This assistance can come directly from the government by providing interest-free loans. Alternatively, the government can encourage non-governmental organisations (NGOs) whose goal is to empower people economically to do so.

This is the official practice in countries such as Ethiopia and Liberia.

To address the problem of reduced accessibility in the wet season, the government or NGOs should assist the IWCs in acquiring motorised carts (tricycles) for waste collection. This will facilitate more effective door-to-door waste collection in both the wet and dry seasons, facilitate waste movement to the approved dumpsites, and encourage the residents to bring out their wastes for evacuation promptly.

The government also needs to sensitise the city's residents, through community development associations, to avoid burning waste within and around their houses, along the local roads, inside drains, or in open spaces within their neighbourhoods. In addition to severe air pollution, with its attendant damaging effects on public health, the burning of waste contributes significantly to the depletion of the ozone layer and consequently leads to global warming.

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